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INVESTIGATIONAL REPORT No. 41

THE BIOLOGY OF GUANO-PRODUCING SEA-BIRDS

The Distribution, Abundance and Feeding Habits of the Cape Penguin, *Spheniscus demersus*, off the South-Western Coast of the Cape Province.

BY

R. W. RAND

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Issued by the Division of Fisheries, Beach Road, Sea Point, Cape Town

Union of South Africa

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1. Summary.

1. During 1954–56 the Cape penguin (*Spheniscus demersus*) was hunted at sea up to ten miles from land between Lambert's Bay and Quoin Point. Two hundred and forty-seven penguins were specially collected and the contents of their stomachs examined.

2. Cape penguins are normally found close to the coasts of southern Africa, from the Kunene River in the north-west to Algoa Bay in the east. They nest on nearly all islands off the South African and South West African coasts and do not migrate, although they may range far from these islands.

3. About 103,000 penguins are permanent residents of eight islands off the coast of the south-western Cape Province.

4. Penguins have a body-weight of about 6½ lb. The greatest weight of food in any stomach was 602 gm. or 1 lb. 6 oz. The mean weight of food in all stomachs was 115 gm. or about 5 oz.

5. Penguins feed on at least 25 different species of fish, three cephalopods, 18 crustaceans and a polychaete. According to numbers present in all stomachs, the Cape penguin feeds chiefly on maasbankers and anchovies (33 per cent) with crustaceans, Round herrings and cephalopods filling minor dietary roles. On the basis of frequency of occurrence, squid (52 per cent) are most important and are followed by anchovies (24 per cent), maasbankers (23 per cent) and pilchards (19 per cent). On the basis of weight, however, the pilchard (32 per cent) dominated anchovies (21 per cent) and maasbankers (18 per cent), the other prey being of comparatively minor importance.

6. Feeding journeys may be three weeks in duration but are usually much shorter. Penguins pursue their prey under water.

7. On the basis of one meal per day, a penguin is estimated to consume about 320 gm. daily. During the calendar year, 103,000 penguins, feeding for 185 days, are thought to consume about 7,000 tons of marine food. Forty-two per cent (2,900 tons) are fish of some economic importance.

2. Introduction.

This report is the second of a series by the author with the object of analysing the predator status of guano-producing sea-birds off the south-western coast of the Cape Province. It deals specifically with the feeding habits of the Cape (Jackass or Black-footed) penguin, *Spheniscus demersus*, in a limited area off the Cape Peninsula and vicinity. These birds were studied at the same time as other sea-birds and seals during the pelagic investigations of 1954–56 (Rand, 1959, 1959 *a*). The scope and technique of this study have been described in previous reports and further discussion of the impact of these and other sea-birds on marine prey is deferred to a later report in which the interrelationships of the different predators will be described. To facilitate comparison, the mode of presentation of this report deliberately follows that of the previous one (Rand, 1959 *a*).

The harvest of guano from some islands comes almost wholly from the penguins. Their stability as a nesting population in the face of interference, their habit of forming dense colonies on rocky ground, and a clear-cut breeding-cycle are general characteristics that make the birds useful to the guano industry. The autumn egg-laying season on Dassen Island is exploited biennially.

Because of its commercial significance, the Cape penguin has enjoyed strict protection for many years; but it is claimed that in conjunction with other guano-producing species, it destroys large quantities of fish of value to man. The investigation of its feeding-habits commenced in 1953 as part of a general study of pilchards in St. Helena Bay (Davies, 1955). This programme was extended in 1954 to other areas off the south-western coast of the Cape Province. During these studies particular emphasis has been placed upon the predator status of the birds.

3. Methods.

Two hundred and forty-seven penguins were collected during 1954–56 from various parts of the inshore zone between Lambert's Bay in the north and Dyer Island in the south-east (see Table 1). The bulk of specimens came from the vicinity of the Cape Peninsula (see Table 2). In Plates III and IV the localities where penguins were captured are shown as small closed circles, the adjacent islands as larger closed circles. No penguins were actually collected north of Cape Columbine after August, 1954, but their presence was recorded during all cruises through St. Helena Bay. Sampling did not follow any pre-determined quota but was governed rather by the opportunities for hunting and ability to examine the bag.

It was perhaps more difficult to capture penguins than any of the other three sea-bird species regularly shot at sea during 1954–56. The rapidity

with which they dived (the name "demersus" means submerged), and the toughness of their skin against small shot often made it necessary to select and approach targets with great care. Numbers 5 and 6 shot (12 gauge) were lethal in most cases.

Stomach contents were analysed according to numbers of prey, their weight and occurrence in individual stomachs. Presentation of results by these three methods attempts to avoid the criticisms inherent in any single method (McAtee, 1912), but no judgment is given of their relative values in assessing the economic importance of the food. Thus one penguin may have taken as long to find and eat 280 stomatopods as another did for three maasbankers, although the total amounts of both prey occupied the same volume and had the same weight.

The behaviour of the penguins at the time of their capture is important in interpreting the status of food in their stomachs. More general details about the life-cycle of the birds are also necessary when interpreting their overall food needs. Because of the lack of details about their life-cycle on land, this report refers to some observations of penguins nesting on Sinclair Island (South West Africa) during 1947–49.

4. Bionomics.

(i) Plumage.

The Cape penguin is distinctively sooty-black on the back but white over the abdomen and thighs; a black strip runs up the side of the body and across the throat. A reddish naked patch over the eyes is prominent during the breeding season. The dark plumage of the back may fade to a light brown at the end of the nesting season. The ventral plumage pattern is illustrated in Plate II.

There are two South American Spheniscidae which are very similar to *demersus* but differ respectively in having an additional band across the throat (*magellanicus*), and a much narrower white band along the side of the head (*humboldti*). It is not known if these species have ever succeeded in reaching the shores of South Africa but another penguin, the Rockhopper, *Eudyptes crestatus*, occasionally does so. The latter species is easily recognised by long white feathers on the side of the head.

Immature penguins do not have the contrasting black and white plumage of breeding birds. They are drab, greyish brown in general appearance. Occasionally immature birds, showing incipient replacement of neck feathers, were encountered at sea.

(ii) Dimensions.

Some large penguins were collected; standard body dimensions (in mm.) were: Length 590 (about 23 inches); flipper 194–202; culmen 54–59. Males were generally larger than females but the distinction is obscured by individual variation and it is difficult to sex birds at random except during the egg-laying period.

The mean (dead) weight of 113 *adult penguins was* 2,547 *gm. or* 6 *lb.* 3 *oz.* (standard deviation 15 oz.). Male penguins captured at sea reached a maximum weight of 9 lb. 14 oz. in June; females reached their maximum weight of 8lb. 9oz. in October. These weights were taken from birds about to moult.

(iii) Breeding Cycle.

Penguins breed twice a year. Although there is much individual variation in the time, two peaks of egg-laying occur during the year, namely in the early spring (September) and in the late summer (February).

From observations of penguins on Sinclair Island, it is known that the incubation period varies from 38 to 41 days. In the case of nine nesting pairs, each bird spent an average of 20 to 22 days on land while incubating the egg, i.e. about 50 per cent of the whole period is spent away from the sea. There is little variation in the length of reliefs between mates but the number of reliefs may vary between different pairs. There is strong synchronization of foraging movements of mated birds during the egg stage. Thus if one of a pair goes to sea for 13 days, so will the other during a subsequent relief.

After the eggs are hatched, adults shorten the length but increase the number of their feeding journeys. It was found that in a fledgling (guard) period of 80 days, the adult birds were about 45 days (56 per cent) at sea.

The breeding cycle and its relation to the presence of birds at sea or on land for a half-year interval can be summarized for ease of computation in this report as shown on next page.

Phase.	Defined length.	Estimated time on land.	Estimated time at sea.
	(days)	(days)	(days)
Pre-nuptial	25	20	5
Incubation	42	20	22
Guard	80	35	45
Pre-moult	20	0	20
Moult	15	15	0

(iv) Moult.

Penguins moult after each breeding cycle, in July and January. They do not enter the water when replacing their feathers. From observations on Sinclair Island, marked birds spent up to 21 days on land during the moult although a spell of 15 days is taken as an average for this phase. The moult is not necessarily synchronized in mated birds. Thus one bird finished moulting 23 days before its mate.

Some penguins return to their old nests 44 days after moulting or about three weeks before the eggs are laid. The post moult or pre-nuptial period involves nearly four weeks, of which 20 days are spent on land and five at sea. The guard or fledgling period merges into the moult but the time between the disappearance of the chicks and the commencement of moulting is about three weeks, almost all of which is spent at sea.

Because penguins moult on land, it is unlikely that signs of the moult will be seen in birds captured at sea. Nevertheless, one emaciated specimen caught during June weighed 4 lb. 6 oz. only, and some old feathers still adhered to its neck. It was the lightest of adult birds handled and demonstrates the extent to which weight is lost during the moult.

At least a year elapses before young penguins lose their drab juvenile plumage. On Sinclair Island immature birds, moulting for the first time, weighed up to 12 lb. 10 oz. (5,716 gm.), a mean weight of 9 lb. 1 oz. being obtained from eight birds weighed when they reached the island. Almost all of these showed signs of the white plumage on the neck but the " bloated appearance " of others was an equally good sign of the incipient moult.

5. Distribution.

Cape penguins are confined to the coast of Southern Africa, occasionally reaching Natal (Amanzimtoti) on the East coast and at least as far as the Kunene River on the West coast (Sclater, 1906).

They nest on all islands (except Robben Island) off this coast (see Plate I). The largest colonies are on Possession, Pomona, Plumpudding, Marcus, Jutten, Dassen and Dyer Islands. By far the greatest concentration of penguins off the south western coast of the Cape Province is that at Dassen Island. Occasional penguins nest on seal rookeries such as Jacob's Reef, Quoin Rock, Geyser Island and Seal Island (False Bay) but only the latter island affords sufficient protection among the loose boulders to maintain a sizeable colony.

(i) Bird Log of R S " *Africana II*, " 1950-53.

Cdr. Thomas (*in MS.*) reports penguins at a maximum distance of 64 miles from the nearest land. They were found over 20 miles from the shore during all months of the year. There were penguins at 13 of the twenty routine stations (A to T) visited by R.S. " *Africana II* " during 1950–53. They were not observed at stations E, S, D, A, B, C which lie between 42 and 76 miles from the coast.

(ii) Pelagic Investigations, 1954-56.

Penguins were encountered in all parts of the search areas, from Lambert's Bay to round the Cape as far as Dyer Island. Plates III and IV show that the birds were frequently seen off Robben Island and Hout Bay.

(iii) Ring Returns.

Penguins ringed on Dassen and Malagas Islands were found near Lambert's Bay, False Bay and Cape Agulhas. These recoveries suggest that the birds disperse widely from their nesting places. However, there are many unsolved problems about the dispersal of both adult and immature birds. Layard & Sharpe (1884), for instance, suggest that the penguins migrate in a body from the islands off South West Africa from the latter

end of March to late in May and can be seen 40 or 50 miles from the land. The exodus may well refer to birds preparing to moult but it is not usually so obvious. Large-scale ringing may elucidate these and associated phenomena in the dispersal of the birds from particular islands.

6. Abundance.

(i) Island Populations.

Numbers of Cape penguins vary greatly at different islands. The smaller rocks such as Hollam's Bird Island accommodate only one or two pairs, but on larger islands many penguins either congregate in colonies or else live as solitary pairs. Scattered nests occur on the shrub-covered Possession Island and Dyer Island in close proximity to large colonies.

To obtain information about the penguin population, a special aerial photographic reconnaissance was made over all islands in November, 1956. Individual penguins could be counted on the enlarged photographs. Preliminary counts of the birds on the various south-western Cape islands gave a round figure total of 103,000 as follows: Lambert's Bay Islet, 50; Malagas Island, 1,100; Marcus Island, 5,900; Jutten Island, 9,500; Vondelings Island, 400; Seal Island, 100; Dassen Island, 80,500 and Dyer Island, 5,000.

The photographic coverage was made at a time when many birds were nesting or rearing chicks. This was unfortunate as the birds have the habit of burrowing or nesting under boulders and they could not be counted with great accuracy. Further details of the census project and a closer analysis of the counts are being prepared for a future report.

(ii) Numbers from Bird Log of R.S. "*Africana II*".

Cdr. Thomas (*in MS.*) during his studies of seabird density at various research stations close to the West coast stations found relatively few penguins during 1950–53. The largest total of 247 birds came from station N, nine miles off shore in St. Helena Bay. Two hundred and nine penguins were counted at station P about four miles from Stompneus. The monthly average of penguins was 32, counted during the nineteen months of observation in the research area.

(iii) Numbers from Pelagic Studies, 1954-56.

Penguins were never numerous in any part of the search areas. From Table 3, the highest number per observation day during 1956 was just over 17 in May. A somewhat similar number (15) came from January. Schools of penguins were occasionally recorded but never exceeded some 50 individuals (these are marked with an asterisk in Table 3). They have not been considered in the more accurate individual counts. The effect of fixed lines of observation on irregular dispersion makes a penguin census at sea somewhat unreliable unless taken over a considerable area and at more frequent intervals than was possible during the present studies.

7. General Account of the Food.

(i) Nature of the Food.

Historically, little has been said about the food of the Cape penguin. Anderson (1866) makes the laconic statement that " the food consists entirely of fish caught by diving, and of these they consume enormous quantities . . .". Roberts (1940), however, concluded that it feeds on marine animals such as crustacea and small fish.

Davies (1956), as a result of investigations in St. Helena Bay and off the Malmesbury coast, established that penguins preyed upon pilchards (*Sardinops ocellata*), anchovies (*Engraulis japonicus*), maasbankers (*Trachurus trachurus*), mackerel (*Scomber japonicus*), sandcords (*Gonorhynchus gonorhynchus*), squid (*Loligo reynaudi*), and crab larvae (*Plagusia*).

Investigations during 1954–56 covering this area and other parts of the coast of the south-western Cape, augment the list (seven species of prey) by at least another 21 prey organisms, namely: Sandeels (*Ammodytes capensis*), Round herring (*Etrumeus micropus*), skippers (*Scomberesox aurita*), windtoys (*Pterosmaris axillaris*), butterfish (*Palunolepis brachydactylus*), mullets (*Liza ramada*), " Sardinhas " (*Sardinella aurita*), ribbonfish (*Lepidopus caudatus*), snoek (*Thyrsites atun*), gurnard (*Trigla queketti*), pipefish (*Syngnathus acus*), horsefish (*Congiopodus spinifer*), jacopevers (*Sebastichthys capensis*), needlefish (*Hemirhamphis far*) and *Petalichthys capensis*), crocodile-tooths (*Champsodon capensis*), rockfish (Clinidae). vlei sardines (*Atherina breviceps*), various cephalopods, crustaceans and polychaetes.

The penguin browses extensively in bays or in the open sea; chance encounters with prey contribute to an almost endless variety in the diet, much of which is only limited by the extent of the feeding journeys and the whereabouts of the prey (mostly juvenile stages). The present investigation failed to detect any marked food preferences and

it is believed that the penguin, like other sea-bird predators, takes prey indiscriminately.

(ii) Weight of Food in Stomachs.

By far the greatest amount of food per penguin (602 grams) came from the month of June. The amount of food (maximum and mean) per bird in other months of the study period is shown in Table 5. The highest monthly mean amount of food per bird came from August. Davies (1956) records a weight of 812 grams from St. Helena Bay. This interesting exception shows the extent to which some penguins may gorge themselves. In St. Helena Bay the average amount of food in 112 stomachs was only 79·6 gm.

The arithmetical mean weight of food in 247 *stomachs of penguins from the south-western coast of the Cape Province was* 114·8 *gm. with a standard deviation of* 135 *gm.*

(iii) Size of Prey.

The largest fish in penguin stomachs was a pilchard about 29 cm. long and weighing 159 gm. (partly digested). It was the only one of its kind, but the stomach in which it was found also held a large maasbanker (length 20 cm.). Such big prey was found in no other stomachs and is considered exceptional. The usual size of prey of this nature is shown in Table 14, and is discussed for other species in subsequent paragraphs.

(iv) Composition by Numbers.

Prey could be counted in many stomachs either as whole individuals or from specific remains (stomach caeca of fish or beaks of cephalopods). In several instances, however, the items were so comminuted that accurate counts were impossible. In spite of this limitation, counts gave the following numbers for the chief prey (inseparable remains augmenting the more accurate counts are marked with an asterisk):—

Engraulis	1,315*
Crustaceans	1,120
Trachurus	824
Etrumeus	786*
Cephalopods	731
Gonorhynchus	227*
Sardinops	207*
Polychaetes	185*

Anchovies and crustaceans were dominant numerically. Maasbankers, Round herrings, sandcords and polychaetes appeared in somewhat similar numbers (see Table 6). At least 398 fish could not be identified but probably belonged to one or other of the listed prey.

According to their *numerical* status in 218 stomachs, fish constituted 68 per cent of all prey, crustaceans 17 per cent, cephalopods 11 per cent and polychaetes three per cent, or in the ratio of:— 25 fish: 6 crustaceans: 4 cephalopods: 1 polychaete.

(v) Composition by Weight.

Fish formed 83 per cent of all material in the stomachs. The remains of cephalopods reached about four per cent of the weight of the contents of these stomachs. Crustaceans and polychaetes were only a fraction of these weights.

The various fish prey were dominated by the pilchard, which represented 32 per cent by weight of all fish; it was followed by the anchovy (21 per cent) and the maasbanker (18 per cent). Fish of major economic importance represented 51 per cent by weight of all fish, and 42 per cent by weight of all prey captured by the penguins. Fish of lesser importance were sandeels (4 per cent), mackerel (3 per cent), Round herrings (7 per cent) and sandcords (1 per cent). Other species did not reach more than one per cent of the weight of fish in all stomachs. Unidentified fish were seven per cent by weight of those that could be identified (see Table 8).

Cephalopod and polychaete weights were very low; in the case of the polychaetes it was only on one or two occasions that the total prey would originally have weighed an appreciable amount, but in the case of the cephalopods, original meals might have weighed as much as the fish.

On the basis of *weight*, the principal prey of the penguin occurs in the following percentage ratio:— 94 per cent fish: 5 per cent cephalopods: 1 per cent crustacean; or 118 fish: 6 cephalopods: 1 crustacean.

(vi) Composition by Frequency of Occurrence.

Table 7 shows that fish were found in 218 (88 per cent) of the 247 penguin stomachs, cephalopods in 131 (53 per cent), crustaceans in 72 (29 per cent) and polychaetes in 23 (9 per cent). Of individual prey, maasbankers (26 per cent) were most frequently taken by the penguins but were closely followed by anchovies (24 per cent) and pilchards (20 per cent). Squid (52 per cent) were by far the most common cephalopod that could be identified, octopus and cuttlefish being found in two only of the 131 stomachs. Stomatopods in over 29 stomachs and polychaetes in 23 were other organisms of importance to the penguin. Juvenile Cape rock lobsters were found in 11 stomachs (about five per cent).

On the basis of frequency of *occurrence*, the main prey occurred roughly in the following ratio:— 49 per cent fish: 29 per cent cephalopods: 16 per cent crustaceans: 6 per cent polychaetes; or 9 fish: 6 cephalopods: 3 crustaceans: 1 polychaete.

(vii) Regurgitations.

Penguins rarely regurgitate their food during handling; indigestible remains are also seldom ejected while the birds roost on land. Regurgitations were not used in identifying food items.

(viii) Fluctuations in Food Consumption.

Seventy stomachs were either quite empty or had food weighing less than 20 gm. Most empty stomachs (20) were noted from October or December. The number of grammes of food per unit weight of body was highest in December, October and September, and lowest in August (see Table 4). Further remarks about seasonal variations in the amount and type of prey are made in Chapter 8.

(ix) Food Differences according to Age.

Eight immature penguins had a mean weight of 34 gm. of food in their stomachs (maximum 151 gm.). They had eaten squid, stomatopods, polychaetes and a few fish such as anchovies, sandeels, maasbankers, harders and clinids. The food traces suggest a tendency to prey on slow-moving prey rather than the off-shore pelagic schooling fish.

8. Individual Food Items.

(i) Fish.

(a) Pilchard (*Sardinops ocellata*).

Pilchards were found in 51 (20 per cent) of the 247 stomachs collected at sea during 1954–56. At least 207 of these fish were counted, a mean of four per stomach. The highest number (25) came from a stomach collected in Hout Bay during May.

Pilchards comprised 32 per cent by weight of all fish food, or 27 per cent of all food taken by the penguins. The fish weighed 7,761 gm. or about 152 gm. per stomach. The heaviest pilchards came from October (mean weight 91 gm.) and May (mean weight 11 gm.). The greatest weight of pilchards (six) in any stomach was 602 gm.

In a sample of 145 pilchards, 44 per cent were of commercial size (16–22 cm. long) and 56 per cent of much smaller size. A large proportion (10 per cent) were less than ten cm. long (see Table 14).

On the basis of occurrence in all stomachs, pilchards were taken most frequently in the winter (June–August) and ensuing months (see Table 7), least so from February to May. Fewer pilchards seem to be taken in the summer and early autumn. They were not recorded during January. Comparatively few pilchards were taken in 1955.

Pilchards were seldom caught by themselves. In 1956 they occurred alone in only five stomachs (11 per cent) but were combined with cephalopods (22 per cent), anchovies (17 per cent), maasbankers (11 per cent), crustaceans (11 per cent) and a variety of other fish in lesser proportions (see Table 11).

Pilchards were taken in all parts of the search areas. From Table 13, 18 per cent of stomachs with pilchards came from the Saldanha Bay area (zone 5), 26 per cent from the Cape Peninsula (zone 3). Fewer came from False Bay than from St. Helena Bay. Pilchards were caught throughout the day, over a temperature range of 11·8° C to 17·2° C.

(b) Maasbanker (*Trachurus trachurus*).

Maasbankers were found in 64 (26 per cent) of the 247 stomachs collected at sea during 1954–56, and constitute the most important food item on this basis. These stomachs contained 824 of this fish, an average of about 13 per stomach. The largest number (136) in any stomach was taken in Table Bay during October. The highest monthly averages per stomach came from May (35), October (22) and September (15).

Maasbankers formed 18 per cent by weight of all fish food or about 15 per cent of all food weighed. The smallest maasbankers were taken in April and May and again in February (mean weight 31 gm.) and August (mean weight 44 gm.).

The bulk (53 per cent) of maasbankers was under 5 cm. long. The maximum length of 20 cm. was measured from a fish caught during October. A single stomach obtained during July contained 86 maasbankers about 8 cm. long. Another stomach obtained during October contained 136 fish from 2 to 4 cm. long.

Maasbankers were taken in all parts of the search area; the bulk of fish (49 per cent) came from the Cape Peninsula (see Table 13). Three stomachs carried maasbankers only but they were otherwise combined with all major prey except

skippers (see Table 11). They were most commonly taken with cephalopods. About twice as many maasbankers were taken in the morning as in the afternoon, over a temperature range of 13·1° C to 18·8° C.

(c) Anchovy (*Engraulis japonicus*).

Anchovies were numerically the principal prey of the penguins, over 1,315 being counted in 59 stomachs (about 22 per stomach). Small anchovies were taken in greater numbers in the autumn (up to 71 per stomach during April) than were larger ones from other months (two per stomach during June). No anchovies were in stomachs collected during January, May or September. About 300 juvenile anchovies were among the highest numbers of fish prey recorded in any stomach (they were exceeded only by stomatopod shrimps and juvenile round herrings). Anchovies occurred in 24 per cent of all stomachs; and were 21 per cent by weight of all fish.

Individual anchovies varied considerably in weight; 1,315 anchovies weighed 5,037 grammes or about 4 gm. each (the mean per stomach was 85 gm.). During the year the mean weight of anchovies fluctuated from one gram each during April to ten grammes each during June. Large anchovies (7–8 gm.) were caught in the summer, smaller ones in the autumn.

Most anchovies (74 per cent) were under 5 cm. and none fell outside the 11–15 cm. length group (see Table 14). Anchovies were never taken alone but appeared with other fish prey, cephalopods, polychaetes and occasionally with crustaceans (see Table 11). About three times as many anchovies were caught in the morning as in the afternoon, over a temperature range of 11·8° C to 16·2° C.

(d) Mackerel (*Scomber japonicus*).

Mackerel were found in 20 stomachs (9 per cent) but their weight was only three per cent of all the fish food. They were caught chiefly in November and December.

Although some small mackerel (5 cm. long) were taken during November, this prey was generally larger, individuals of up to 23 cm. (recorded weight 62 gm.) being taken in June.

The bulk of stomachs with mackerel was collected round the Cape Peninsula; half as many came from St. Helena Bay. Mackerel were found with pilchards, maasbankers, skippers, cephalopods and crustaceans (see Table 11). They were taken in the morning and afternoon in about equal numbers, over a temperature range of 12·7° C to 14·9° C.

(f) Sandeel (*Ammodytes capensis*).

Sandeels occurred in 16 (6 per cent) of the 247 penguin stomachs collected at sea. They comprised four per cent by weight of all fish food. Largest numbers came from June (average 67 fish per stomach) and February (average 43 fish per stomach). In both months the mean weight of sandeels varied from 2 to 8 gm. each. Larger fish (up to 10 gm.) came from stomachs collected during the late spring.

Although penguins occasionally feed on sandeels exclusively, these were also taken with pilchards, maasbankers and anchovies. Most sandeels came from bays along the Cape Peninsula but were also fairly evenly distributed elsewhere over the search areas. They appeared to be taken more often in the morning than in the afternoon. Sandeels captured during March had eaten euphausiids, the disintegrated remains of which appeared in the penguin stomachs. The fish were taken over a temperature range of 11° C to 18·8° C.

(g) Round Herring (*Etrumeus micropus*).

Nineteen stomachs (8 per cent) contained round herrings; the weight of these fish was seven per cent of all fish food. Juvenile round herrings were taken in greater numbers by individual penguins than any other prey, 380 (total weight 110 gm.) being counted in a stomach obtained near Danger Point during June. All fish from other stomachs were under 15 gm. and measured less than 15 cm. long.

Most Round herrings came from the west side of the Cape Peninsula (none from False Bay). They were taken with pilchards, maasbankers, anchovies, sandcords, cephalopods, crustaceans and polychaetes (see Table 11). Round herrings were captured at all times of the day, over a temperature range of 11·8° C to 17·2° C.

(h) Skipper (*Scomberesox saurus*).

Skippers (or garfish) were encountered in three stomachs only, but are believed to be an important species of prey for penguins foraging far off shore. They were taken in February, September and December from the Cape Peninsula (Cape Point and vicinity) and from Saldanha Bay.

Skippers were found with pilchards, anchovies, mackerel and cephalopods. They had been eaten in the morning and the afternoon. One specimen was taken at 12° C surface temperature.

(i) Mullet (*Liza ramada*).

Mullets were found in two stomachs from the Cape Peninsula (Sand Bay). The surface temperature at the time of collection was 11° C.

"Sardinha" (*Sardinella aurita*).

Nineteen "sardinhas" were found in a single stomach from St. Helena Bay during December.

(k) Windtoy (*Pterosmaris axillaris*).

Windtoys occurred in two stomachs (Table Bay and Cape Columbine).

(l) Butterfish (*Palunolepis brachydactylus*).

Three butterfish (or steenklip fish) appeared in a single stomach containing a windtoy, sandcord, sandeels, cephalopod and mysid crustaceans from Cape Columbine (October).

(m) Ribbonfish (*Lepidopus caudatus*).

Thirty-five ribbonfish were found in a stomach from Robben Island, one from another stomach collected near Vondelings Island (both during February).

(n) Snoek (*Thyrsites atun*).

A juvenile snoek weighing 20 gm. was caught by a penguin off Llandudno (Hout Bay) in January.

(o) Gurnard (*Trigla queketti*).

Juvenile gurnards appeared in three stomachs from the West coast search areas. Another stomach held the remains of a single large-sized gurnard. They were all taken during February, March, July and November.

(p) Pipefish (*Syngnathus acus*).

Three stomachs from November and December contained single pipefish, taken near Hermanus, Cape Point and Vondelings Island.

(q) Horsefish (*Congiopodus spinifer*).

A single juvenile horsefish appeared in a stomach from Hout Bay (April).

(r) Jacopever (*Sebastichthys capensis*).

Seventeen juvenile jacopevers were found in a stomach from Table Bay (February).

(s) Crocodile-tooth (*Champsodon capensis*).

A single *Champsodon* was found in a stomach from Hout Bay (April). Squid, shrimps, sandeels, maasbankers, eels (*Ariosoma*) were other prey taken by this penguin in the mid-morning.

(t) Needlefish.

A single needlefish (*Hemirhamphis far*) was in one stomach from Cape Point (December). A number of squid had been captured by this penguin soon afterwards.

Three other needlefish (*Petalichthys capensis*) were taken off Vondelings Island during February.

(u) Eels.

Fifty-nine bocavantes (*Ariosoma balearica*) were found in a stomach from Hout Bay (April), 91 and one respectively in two other stomachs from the same area during other months. Some eels reached 22 cm. in length.

Nineteen *Conger conger* were found in a stomach obtained near Dassen Island during March. A single *Leptocephalus* was found near Ysterfontein in November and is provisionally classified as a juvenile *Conger*.

A single juvenile sandsnake (*Ophisurus serpens*) appeared in a stomach from Camps Bay (April). There were in addition to this prey, 76 maasbankers, a stomatopod and some unidentified juvenile fish.

(v) Vlei Sardine (*Atherina breviceps*).

A single penguin had eaten vlei sardines during December.

(w) Rockfish.

Clinids and blennies were found in four stomachs from St. Helena Bay, Table Bay en Dassen Island. The fish were mostly taken singly but four clinids were in one stomach from Hout Bay (November). Juvenile blennies were especially numerous off Dassen Island during November and were associated with other juvenile fish such as maasbankers, round herrings and sandcords. The surface temperature range was from 11° C to 14·9° C.

(x) Unidentified fish.

Unidentified fish appeared in 79 (36 per cent) of the 218 stomachs with fish. This high proportion of unidentified fish is due to the difficulty of separating triturated remains of juvenile stages. While it is believed that most of the fish belonged to the species listed above, it is possible of course, that other unnamed prey was also present.

(ii) Cephalopods.

Cephalopods were found in combination with all other prey except skippers, and were alone in only three stomachs. They occurred in 131 (53 per cent) of the collection of 247 stomachs. Their weight was insignificant (4 per cent) as they were represented chiefly by beaks and small pens.

The stomachs contained 731 cephalopods, a mean of six per stomach. The greatest number in any stomach was 243 from June. Large numbers of squid were taken in mid-winter and mid-summer (see Table 9). The dominant cephalopod was the squid with occasional sea-cats and very rarely cuttlefish, taken over a temperature range of 11° C to 16° C.

(iii) Crustaceans.

Penguins occasionally fed on surface crustaceans such as megalopa larvae and mantis shrimps. At least 18 different crustaceans were found in 72 (29 per cent) of the 247 stomachs; their relative abundance in some stomachs showed that the penguins had actively taken them as food (see Tables 9 and 10).

Stomatopods were by far the most abundant of the crustacean prey, there being nearly 150 mantis shrimps (*Squilla armata*) in fourteen stomachs. Larval stomatopods considered to belong to this species, were especially abundant in stomachs from the autumn, over 500 being counted from 27 stomachs (one stomach contained 376 of these shrimps). The surface temperature range was 12·4° C to 14·9° C.

Euphausiids were recorded from three stomachs. During mid-February, an adult penguin had captured 260 euphausiids which packed the stomach to the exclusion of other foods (the weight was only 35 gm.). During April numerous small euphausiids (*Nyctiphanes capensis*) were eaten a few miles south of Dassen Island in the afternoon (these crustaceans were collected during 1955 but did not appear in stomachs from 1954 or 1956. Nepgen (1957) commenting on hauls of euphausiids in February, 1955, near Saldanha Bay, found a distinct bloom in abundance during the warm months of that year.

Hyperia was the common amphipod, appearing in four stomachs but it was not taken to the same extent as euphausiids or stomatopods. Other amphipods were the pelagic *Paramoeia* and *Euthemisto*.

Unidentified parasitic isopods occurred in three stomachs. Other isopods were *Paridotea*, juvenile *Cymathoe*, *Cirolana* and *Eurydice*, each species found singly in the respective stomachs.

Unidentified parasitic copepods occurred in two stomachs.

Decapods were represented chiefly by juvenile Cape rock lobsters (*Jasus lalandii*) in ten stomachs. One penguin had eaten 81 of these young crustaceans in February. A cracker-shrimp (*Ogyrides*) was found in May. Two juvenile rock lobsters (*Palinurus*) appeared in one stomach. Penaeid shrimps were eaten in March. Megalopa larvae appeared in seven stomachs and were apparently taken throughout the year, 27 being eaten by one bird in October.

Unidentified crustaceans, possibly belonging to the above groups, were found in six stomachs. They were fragmentary and had obviously been in the stomachs long before collection.

(iv) Polychaetes.

The remains of polychaetes were found in 23 stomachs. A stomach collected near Marcus Island (Saldanha Bay) contained a complete specimen of the heteronereid stage of *Nereis operta*. Other stomachs held traces only. The largest number of penguins eating nereid worms was noted in the period July to October. The temperature range over which these birds were caught was 11·8° C to 16·2° C.

(v) Miscellaneous Items.

Broken pieces of small gasteropod shells were occasionally found; stones once only. A sponge, byssus attachment of *Mytilus*, feathers, an alcyonarian bud and liquid were among debris in a few stomachs. Nematodes and cestodes (two instances) were also found in the stomachs.

9. Feeding Habits.

(i) Feeding Journeys.

Large numbers of penguins were encountered off the Cape Peninsula at Hout Bay, Cape Point and elsewhere along the western coast. These areas are at least 50 miles from Dyer Island and 60 miles from Dassen Island (Seal Island in False Bay, of course, lies much nearer but the numbers of penguins sighted off the Cape Peninsula do not all come from there). The birds move at least 150 miles on feeding journeys to and from the islands. All this distance is potential foraging range but it is improbable that the penguins hunt when returning to a rookery.

Furthermore, penguins have been sighted in the open sea 64 miles from land. Present studies do not show that they are restricted to special inshore feeding grounds. Theoretically, the feeding zone for a particular colony covers at least 4,000 square miles (about 65 by 60 miles). This is modified during various seasons and the penguins may travel far beyond these limits. The whole (population) foraging area from Lambert's Bay to Dyer Island would be about 13,000 square miles (65 by 200 miles). The pelagic cruises were confined to the inshore up to ten miles from land and usually much nearer; penguins were scattered over all this

area. In calm weather the birds may hunt among the kelp but they usually keep well away from the rocky coast.

Meinertzhagen (1955) calculated that an Adelie penguin (*Pygoscelis adeliae*) travelled at 8·1 to 8·5 miles per hour under water for 68 feet. The Cape species is believed to move at somewhat similar speeds but the mode of travelling for relatively short distances (a few hundred yards) and surfacing frequently prevents ranging far at an average speed of this order.

The duration and frequency of feeding journeys are influenced by the particular responsibilities of the breeding season, availability of food and various obscure and interrelated factors such as inclement weather and food needs. Penguins appear to stay at sea all the time when away on a feeding journey and usually do not visit rookeries other than their own. Some indication of the time spent foraging is given in the following table for a pair of marked penguins (Nos. 162 and 133) observed at Sinclair Island in the course of observations spread over two years, 1947–48:—

Phase.	162 ♀ Number of days away from nest.	133 ♂ Number of days away from nest.	Duration of phase.
Pre-egg	0 (2)*	0 (1)*	8 (20)*
Incubation	19 (15)*	21 (24)*	41 (39)*
Guard	22 (18)*	14 (19)*	33 (37)*

* 1948 season.

In 1947 the female of this pair spent an additional 20 per cent of her time at sea after incubation but the male actually spent less time in the water when guarding and feeding a chick. Somewhat similar trends were recorded during 1948.

The pre-nuptial (pre-egg) stage may involve fasting for nearly three weeks (20 days), and the penguins, especially the males, rely on fat accumulated during previous feeding journeys. During incubation the birds alternate their feeding journeys, staying away from land for as much as 13 days at the beginning of incubation but only three to five days later. When the chicks are hatched, one or other parent is not absent for more than four days and usually only for a day at a time, leaving in the early morning and returning during the late evening. In *Megadyptes antipodes*, Richdale (1951) was unable to find any correlation between the duration of absence and the quantity of food given to the chicks on return to land. This aspect was not studied during field work on Sinclair Island.

(ii) Pattern of Feeding.

When returning from feeding journeys, penguins reach land throughout the day and early evening. No observations could be made at sea during the night but in Buffels Bay on one occasion two penguins approached the anchored patrol-boat well after dark to take bait from fishing lines. Apart from this isolated instance, the extent of nocturnal foraging is virtually unknown. Penguins caught in the early morning were empty or had obviously not captured prey for several hours. The luminosity of certain prey, however, may enable the birds to hunt during darkness.

Penguins catch their prey under water. The arrangement of scars on the upper surface of fish prey suggests that they were seized from beneath; small fry are ingested whole. Marks on the body show that larger fish are manipulated in the beak before swallowing so that they pass down the throat head-first. Prey are usually swallowed under water, papillae at the base of the tongue of the penguin being special adaptations against losing the prey when swallowing. The birds occasionally surface to complete swallowing. There is only one record of a penguin taking bait from commercial pilchard fishing boats (False Bay).

Of the specimens collected during 1956, 46 per cent were alone at the time of their capture, the others being in groups of from 2 to 50. A mean weight of 131·2 gm. of food was found in the solitary birds, and 135·5 gm. of food in the others. Penguins collected from large mixed feeding flocks

had an average of 104·5 gm. of food but hunting pairs averaged 144·8 gm. It seems that the birds hunt equally well alone as in the large groups.

In group feeding, bands of penguins attack prey without any observed co-ordination or scheme of hunting. Attacks from below a shoal presumably give the penguins a wider choice of prey than if made from the side. Penguins capture crustaceans near the surface by simply swimming after them.

(iii) Efficiency of Hunting.

Five penguins shot in Walker Bay (December) between 0810 and 0940 SAST had not succeeded in finding prey. Three penguins shot in Table Bay (January) between 0900 and 0950 SAST had less than 50 gm. food (one bird had caught three mackerel). Two penguins caught in Table Bay (May) shortly after 0900 SAST had 2 and 82 maasbankers respectively; another bird had found only 49 stomatopods (weight 20 gm.). Another penguin shot in the same place at 1305 SAST had eaten 86 maasbankers, five stomatopods and three unidentified juvenile fish (total weight 503 gm.).

These instances suggest wide variations in the ability to locate and deal with prey. Even when prey is abundant, individual efforts may vary. Thus three penguins caught the following prey off Robben Island to a rather different extent:—

Time of Capture (SAST).		
0850.	0850.	0910.
242 *Engraulis.*	300 *Engraulis.*	34 *Engraulis.*
6 *Trachurus.*	6 *Trachurus.*	7 *Trachurus.*
1 *Sardinops.*	—	—
5 *Stomatopods.*	16 *Stomatopods.*	14 *Stomatopods.*
—	9 Unidentified fish.	4 Squid.
TOTAL: 306 gm.	343 gm.	117 gm.

(iv) Time of Feeding.

Penguins shot before 0800 SAST were usually empty or had little food (mostly traces) in their stomachs. Relatively high weights were found in stomachs throughout the day, the highest hourly average of 119 gm. being taken between 1400 and 1500 SAST (see Table 15). There appeared to be no evident peaks of feeding activity.

(v) Food in Captivity.

Cape penguins have been kept in captivity for many years and are a popular species of cage bird that thrives in European zoos. Albritton (1954) notes how a Rockhopper penguin (*Eudyptes*), weight 3 kg., of somewhat similar size to an adult Cape penguin, received a total weekly feed of 4 kg., or about 190 gm. of food per kg. of body-weight per day. Dr. E. M. Land, Director of the Basle Zoological Gardens, informs me that Cape penguins eat five or six fish daily, a weight of about 500–600 gm. Penguins are kept in a healthy condition on 8 to 20 per cent of their weight as food per day.

Wackernagel (1952) described the artificial rearing of two Cape penguins in the Basle Zoo. By their seventh week these birds were given 1,575 gm. of food or roughly 788 gm. each. They later weighed 5·5 kg. which alarmed Wackernagel into thinking that they were over-fed. There are at least three records of chicks reaching 1,200 gm. bodyweight in their fourth week of age. Young birds weigh from 4 lb. 9 oz. (2,044 gm.) to 6 lb. 5 oz. (2,228 gm.) when they leave the nests for the first time at 11 to 15 weeks old. Higher weights up to 12 lb. 10 oz. or 5,656 gm. for moulting immature penguins were recorded from Sinclair Island during 1948. A single immature male (exact age unknown) caught at sea weighed 9 lb. 15 oz. (4,502 gm.), more than any of the adult birds.

From studies of captive penguins, Davies (1956) found that 24 per cent of pilchards originally weighing 192 gm., were digested after two hours and 74 per cent after four hours. He considered that after four hours the stomach is three-quarters evacuated and normally feeding would start long before this. It is not at all certain whether this high rate of evacuation applies to birds in the wild.

10. Discussion.

(i) Tempo of Feeding.

The capacity of the alimentary canal controls feeding and affects the frequency of feeding journeys. Nesting penguins appear to make repeated trips to sea to replenish the stock of food for chicks. Thus 195 gm. was given to a 23 day old chick in one day but when only one chick is at the nest, the same parent may well give more. The amount of food needed to satisfy the parent bird itself is not known.

Some penguins reaching the islands at the end of the day have had relatively fresh food in their stomachs. Others captured at sea in the late afternoon have also carried prey hardly affected by digestion in the stomach. It is not easy to calculate when the prey was actually caught but there are indications that evacuation of the stomach is retarded during hunting or when travelling from the feeding grounds. It appears, too, that evacuation of an incompletely-filled stomach is more rapid than that of a full one.

(ii) Meals.

The amount and nature of meals vary greatly. Food combinations listed in Tables 11 and 12 show that the penguin seldom takes a single prey species. In St. Helena Bay, for instance, one bird out of six captured during August when feeding on pilchards, had also taken small squid. The association of different species of fish and other marine animals adds considerable variety to the meals.

Pilchards were the largest individual prey but no more than six adult pilchards were taken at any meal. From the position of the prey in stomachs of three penguins which had eaten these fish, one stopped after catching five pilchards and turned to squid; another penguin took four pilchards but ingested a fifth which weighed nearly 30 per cent of the food already in the stomach. All these birds had food weighing from 420 to 582 gm. and appear to have virtually completed their meals.

Penguins feeding in the same area would be expected to take roughly similar meals. Field observations seem to confirm this. Thus 12 penguins collected outside Saldanha Bay during July had encountered a shoal of anchovies. The amount of food in their stomachs according to the time of capture was as follows: —

No. 4072 at 1000 SAST, one squid (total weight 9 gm.);
No. 4066 at 1015 SAST, no fresh prey;
No. 4063 at 1020 SAST, 19 anchovies (weight 120 gm.);
No. 4060 at 1020 SAST, 31 anchovies (weight 200 gm.);
No. 4065 at 1025 SAST, 13 anchovies (weight 96 gm.);
No. 4061 at 1030 SAST, 31 anchovies (weight 169 gm.);
No. 4067 at 1030 SAST, 11 anchovies (weight 72 gm.);
No. 4070 at 1040 SAST, 93 anchovies (weight 455 gm.);
No. 4062 at 1040 SAST, 23 anchovies (weight 163 gm.);
No. 4059 at 1045 SAST, 28 anchovies (weight 172 gm.);
No. 4068 at 1050 SAST, no fresh prey; and
No. 4071 at 1115 SAST, 5 anchovies (weight 24 gm.).

Penguins may encounter prey in sufficient quantities to enable them to fill their stomachs in a few minutes, or else they spend several hours searching for prey. The concept of a meal is rather different in these cases. When a bird continually takes small prey in a short while, the meal becomes a measurable amount in relation to time and space. But when it only gradually fills its stomach after searching over a wide area, the protracted " meal " has a different meaning.

Penguins with food weighing more than 200 gm. had usually taken a large meal within a short period. These meals are analysed in Table 16, where virtually all the food belonged to recent meals; only five birds had taken prey long beforehand. On this classification of food into meals, it was found that in the case of large amounts, no trace of previous meals was evident except as cephalopod beaks and otoliths. Some penguins had completely evacuated their stomachs before commencing the new meal. Because of these clearly-defined amounts, it appears that successive meals of normal magnitude are rarely taken during the same day. The meal can then be used as a direct measure of the daily consumption. Penguins feeding over several days appear also to have a maximum intake but how this is correlated with the daily intake is not known.

A mean weight of 341 gm. was found in 45 " full " stomachs with food over 200 gm. *Meals, however, were found to have a mean weight of* 320 *gm. with a maximum of* 602 *gm.* (see Table 16).

(iii) Consumption of Food.

During the 1954–56 studies the mean weight of food in 247 stomachs was 114·8 gm. (S. 135 gm.). According to Simpson & Roe (1938), six times the standard deviation gives a close approximation of the range of the sample. On these premises, the statistical maximum amount of food is not likely to exceed 810 gm. or 1 lb. 13 oz. per day.

The greatest weight of food in all the stomachs was 602 gm. from a penguin collected at 1205 SAST. It is improbable that this bird would have resumed feeding the same day. Davies (1956) recorded a weight of 812 gm. from a penguin captured in St. Helena Bay. This led him to assume that " the total possible intake may be closer to 1,000 gm.". These high food weights are exceptional (in 1954–56 only 4·4 per cent of specimens had more than 50 per cent of the theoretical maximum weight of food in their stomachs).

Because of the small number of penguins which ingest even half the statistical maximum, a more reasonable measure of the food intake is the mean weight of the meal (320 gm.=11 ounces) considered here to be synonymous with the mean daily intake.

On the basis of 320 gm. of food daily, the penguin population (103,000) of the south western Cape, feeding at this rate for 185 days of a calendar year, would consume—

$$\frac{103{,}000 \times 320 \times 185}{2{,}000 \times 28 \times 16} = 6{,}800 \text{ short tons.}^*$$

Because of its ability to move far from the land, the penguin feeds over a wide area (considered here to be 13,000 square miles) and the amount of food extracted by a population from specific areas is proportionally less.

11. Conclusions.

The investigation showed that in terms of man's interests, the penguin feeds on a great variety of marine foods only two of which are of immediate commercial interest. Because of their catholic tastes and wide dispersal, the penguins are not likely to develop detrimental feeding habits in particular areas.

* *Note.*—Where this amount concerns commercial fish, it must be reduced by about 58 per cent to give a tonnage of 2,900 of immediate economic interest. This calculation however, is mostly based on the predation of immature stages; whether these will all reach commercial size and be taken by man is open to doubt. No allowance is made for mortality other than by the penguin predator. If such factors are applied, they would further confuse a method of computing which is already beset by too many assumptions, most of which are as yet unproven.

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14. Appendix.

TABLE 1.—Number and Sex of Penguins collected each Month at Sea during 1954–56.

Month.	1954.			1955.			1956.		
	Males.	Females.	Total.	Males.	Females.	Total.	Males.	Females.	Total.
January.....	—	—	—	2	2	5*	2	2	5*
February....	—	—	—	2	6	9*	9	1	10
March.....	—	—	—	2	6	8	2	7	9
April.....	—	—	—	10	7	17	3	3	7*
May.....	—	—	—	3	4	7	2	6	8
June.....	7	4	11	4	3	7	1	4	5
July.....	8	10	18	—	—	—	7	2	9
August.....	6	1	7	—	—	—	3	3	6
September...	4	2	6	2	1	3	2	2	4
October.....	5	6	11	2	10	13*	4	1	6*
November...	2	8	12*	1	4	5	3	7	10
December....	10	5	16*	2	6	8	2	2	5*

* Includes unsexed specimens.

TABLE 2.—Numbers of Penguins collected in various Areas during 1954–56.

Month.	Reference Areas.						Total.
	1.	2.	3.	4.	5.	6.	
January.....	—	—	3	7	—	—	10
February.....	—	5	7	7	—	—	19
March.....	—	7	5	5	—	—	17
April.....	—	—	15	6	3	—	24
May.....	—	—	15	—	—	—	15
June.....	2	2	14	2	3	—	23
July.....	—	9	—	4	15	—	28
August.....	—	2	1	1	2	6	12
September.....	4	—	5	3	1	—	13
October.....	2	1	17	4	4	2	30
November.....	6	—	7	6	3	5	27
December.....	5	—	12	1	—	11	29

TABLE 3.—Numbers of Penguins encountered at Sea during 1956.

Month.	Number of observation days.	Total counted.	Number per observation day.
January.....	3	34*	12*
February.....	6	60*	10*
March.....	8	19	2
April.....	4	25	6
May.....	4	68*	17*
June.....	2	4	2
July.....	5	9*	2*
August.....	6	27*	5*
September.....	5	45	9
October.....	8	77*	10*
November.....	6	25*	4*
December.....	2	2*	1*

* Denotes additional Flocks of up to 50 penguins.

TABLE 4.—Fluctuation of Food consumption in 91 Penguins collected at Sea during 1954–56.

Month.	Number of specimens.	Total body weight.	Average body weight.	Total weight of food.	Average weight of food.	Grams of food per body. weight.
		(oz.)	(oz.)	(gm.)	(gm.)	
January	3	268	89	120	40	0·5
February	9	809	89	501	55	0·6
March	8	855	107	556	69	0·6
April	17	1,715	101	2,170	127	1·2
May	7	685	98	950	136	1·4
June	15	1,525	101	1,659	111	1·1
July	18	1,726	96	2,030	113	1·2
August	1	102	102	5	5	0·1
September	3	306	102	643	214	2·1
October	3	319	106	600	200	2·0
November	6	531	88	304	51	0·6
December	1	113	113	453	453	4·0

TABLE 5.—Weights of Food in 226 Stomachs of Penguins collected at Sea during 1954–56.

Month.	1954.				1955.				1956.			
	Total.	Number.	Maximum.	Mean.	Total.	Number.	Maximum.	Mean.	Total.	Number.	Maximum.	Mean.
January	—	—	—	—	177	4	111	44·3	515	5	231	103
February	—	—	—	—	501	9	148	55·7	1,464	9	398	162·7
March	—	—	—	—	556	6	187	94·3	1,214	8	342	151·7
April	—	—	—	—	2,170	17	343	127·9	679	7	201	97
May	—	—	—	—	950	7	503	135·7	1,276	8	555	159·5
June	1,547	10	550	155	734	5	602	146·8	1,309	4	560	327·2
July	2,030	17	555	119	—	—	—	—	1,259	9	449	139·7
August	1,883	7	582	269	—	—	—	—	519	4	364	129·7
September	107	6	56	18	643	2	413	321·5	239	2	209	119·5
October	1,605	11	474	146	1,109	11	271	100·8	425	6	245	70·9
November	699	12	151	59	491	5	160	98·2	1,197	10	313	119·7
December	1,821	15	453	122	101	6	51	16·8	1,130	5	377	226

TABLE 6.—Numbers of Fish in 218 Stomachs of Penguins captured at Sea during 1954–56.

Species.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.
Trachurus	23	7	23	127	173	5	—	9	45	237	89	86
Engraulis	—	97	112	643+	—	4	225	10	—	124+	41+	59
Sardinops	—	7	3	34	25	30	16	20	7	8	14	43+
Scomber	3	1	—	2	—	1	2	—	—	—	34	25
Gonorhynchus	—	150	—	17+	—	7	3	—	—	4	27	20
Ammodytes	—	43	40	4	—	67	—	—	—	1+	12	33
Etrumeus	—	—	—	103	126	447	—	1	—	—	30+	80+
Scomberesox	—	10	—	—	—	—	—	—	1	—	—	2
Liza	—	—	—	—	—	—	—	—	—	6	5	—
Sardinella	—	—	—	—	—	—	—	—	—	—	—	19
Pterosmaris	—	—	—	1	—	—	—	—	—	1	—	—
Palunolepis	—	—	—	—	—	—	—	—	—	3	—	—
Lepidopus	—	36	—	—	—	—	—	—	—	—	—	—
Thyrsites	1	—	—	—	—	—	—	—	—	—	—	—
Trigla	—	1	1	—	—	—	1	—	—	—	1	—
Syngnathus	—	—	—	—	—	—	—	—	—	—	4	1
Congiopodus	—	—	—	1	—	—	—	—	—	—	—	—
Sebastichthys	—	17	—	—	—	—	—	—	—	—	—	—
Champsodon	—	—	—	1	—	—	—	—	—	—	—	—
Hemirhamphis	—	—	—	—	—	—	—	—	—	—	—	1
Atherina	—	—	—	—	—	—	—	—	—	—	—	30+
Ariosoma	—	—	—	151	—	—	—	—	—	—	—	—
Conger	—	—	19	—	—	—	—	—	—	—	1	—
Ophisurus	—	—	—	1	—	—	—	—	—	—	—	—
Blennidae	—	—	—	—	—	—	—	—	—	—	22	—
Clinidae	—	—	—	—	—	—	—	—	—	—	23	70+
Unidentified	7	16+	3+	55+	10+	6	30+	?	?	17+	15+	239+

TABLE 7.—Frequency of Occurrence of Fish in 247 Stomachs of Penguins captured at Sea during 1954–56

Species.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total.
Trachurus	2	3	3	11	5	1	0	2	3	11	12	11	64
Engraulis	0	6	3	9	0	2	10	1	0	11	8	9	59
Sardinops	0	2	2	5	1	8	6	7	4	4	7	5	51
Scomber	1	2	0	1	0	1	1	0	0	0	6	8	20
Gonorhynchus	0	1	0	3	0	1	2	0	0	3	6	3	19
Ammodytes	0	1	4	2	0	1	0	0	0	2	3	3	16
Etrumeus	0	0	0	2	4	2	0	1	0	0	7	3	19
Scomberesox	0	1	0	0	0	0	0	0	1	0	0	1	3
Liza	0	0	0	0	0	0	0	0	0	1	1	0	2
Sardinella	0	0	0	0	0	0	0	0	0	0	0	1	1
Pterosmaris	0	0	0	1	0	0	0	0	0	1	0	0	2
Palunolepis	0	0	0	0	0	0	0	0	0	1	0	0	1
Lepidopus	0	2	0	0	0	0	0	0	0	0	0	0	2
Thyrsites	1	0	0	0	0	0	0	0	0	0	0	0	1
Trigla	0	1	1	0	0	0	1	0	0	0	1	0	4
Syngnathus	0	0	0	0	0	0	0	0	0	0	2	1	3
Congiopodus	0	0	0	1	0	0	0	0	0	0	0	0	1
Sebastichthys	0	1	0	0	0	0	0	0	0	0	0	0	1
Champsodon	0	0	0	1	0	0	0	0	0	0	0	0	1
Hemirhamphis	0	0	0	0	0	0	0	0	0	0	0	1	1
Atherina	0	0	0	0	0	0	0	0	0	0	0	2	2
Ariosoma	0	0	0	3	0	0	0	0	0	0	0	0	3
Conger	0	0	1	0	0	0	0	0	0	0	1	0	2
Ophisurus	0	0	0	1	0	0	0	0	0	0	0	0	1
Unidentified	7	9	6	11	7	4	8	2	5	5	7	8	79

TABLE 8.—Weight of Fish in 247 Stomachs of Penguins captured at Sea during 1954–56.

Species.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Trachurus	370	216	366	242	881	70	—	400	366	840	275	206
Engraulis	—	359	259	835	—	39	1,665	60	—	1,032	329	459
Sardinops	—	400	250	380	540	1,998	1,148	1,784	270	779	195	137
Scomber	52	59	—	120	—	62	30	—	—	—	245	213
Gonorhynchus	—	50	—	65	—	10	18	—	—	15	165	55
Ammodytes	—	100	389	8	—	560	—	—	—	17	60	30
Etrumeus	—	—	—	168	676	419	—	10	—	—	380	—
Scomberesox	—	200	—	—	—	—	—	—	10	—	—	—
Liza	—	—	—	—	—	—	—	—	—	68	50	—
Sardinella	—	—	—	—	—	—	—	—	—	—	—	100
Pterosmaris	—	—	—	2	—	—	—	—	—	5	—	—
Palunolepis	—	—	—	—	—	—	—	—	—	15	—	—
Lepidopus	—	250	—	—	—	—	—	—	—	—	—	—
Thyrsites	20	—	—	—	—	—	—	—	—	—	—	—
Trigla	—	15	2	—	—	—	50	—	—	—	trace	—
Syngnathus	—	—	—	—	—	—	—	—	—	—	7	5
Congiopodus	—	—	—	5	—	—	—	—	—	—	—	—
Sebastichthys	—	20	—	—	—	—	—	—	—	—	—	—
Champsodon	—	—	—	5	—	—	—	—	—	—	—	—
Hemirhamphis	—	—	—	—	—	—	—	—	—	—	—	20
Ariosoma	—	—	—	345	—	—	—	—	—	—	—	—
Conger	—	—	30	—	—	—	—	—	—	—	5	—
Ophisurus	—	—	—	1	—	—	—	—	—	—	—	—
Unidentified	34	41	29	162	39	24	169	2	148	97	170	710

TABLE 9.—Numbers of Cephalopods, Crustaceans and Polychaetes in 247 Stomachs of Penguins captured at Sea during 1954–56.

Species.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Cephalopods	20	33	18	43	18	287	48	10	18	91	85	60
Crustaceans—												
Decapods—												
Jasus	1	85	—	15	—	—	—	—	—	8	—	+
Ogyrides	—	—	—	—	1	—	—	—	—	—	—	—
Palinurus	—	—	—	—	—	—	—	—	2	—	—	—
Penaeidae	—	—	1	—	—	—	—	—	—	—	—	—
Megalopa	—	1	—	—	—	—	6+	—	—	27	2	1
Amphipods—												
Hyperia	+	1	1	—	+	—	—	—	—	—	—	—
Paramoeia	—	—	—	+	—	—	—	—	—	—	—	—
Euthemisto	—	—	—	+	—	—	—	—	—	—	—	—
Unidentified	—	—	—	+	—	—	—	—	—	—	—	—
Stomatopods—												
Squilla	—	2	—	38	49	43	—	—	—	—	—	16
Unidentified	—	98	+	376	5	—	—	3	15	13	1	3
Euphausiids	—	260	—	18+	—	—	—	—	—	—	—	—
Isopods—												
Paradotea	—	—	—	—	—	—	—	—	—	—	1	—
Cymothoe	—	—	—	—	—	—	—	—	—	1	—	—
Cirolana	—	—	—	—	—	4	+	—	1	—	—	—
Eurydice	—	—	—	—	—	—	1	—	—	—	—	—
Unidentified	+	—	—	—	4	—	—	—	—	—	—	1
Mysids	—	—	—	—	—	—	—	—	—	3	+	—
Copepods	—	—	—	—	—	—	—	—	—	2	1	—
Unidentified	—	—	—	—	1	1+	5	—	—	—	5+	—
Polychaetes	—	4	—	2	1	1	25	10	15	111	16	—

The sign + indicates an undetermined number.

TABLE 10.—Frequency of Occurrence of Cephalopods, Crustaceans and Polychaetes in 247 Stomachs of Penguins captured at Sea during 1954–56.

Species.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Cephalopods	5	11	6	11	8	8	13	4	7	22	14	21
Crustaceans—												
Decapods—												
Jasus	1	2	—	2	—	—	—	—	—	4	—	1
Ogyrides	—	—	—	—	1	—	—	—	—	—	—	—
Palinurus	—	—	—	—	—	—	—	—	2	—	—	—
Penaeidae	—	—	1	—	—	—	—	—	—	—	—	—
Megalopa	—	1	—	—	—	—	2	—	—	1	2	1
Amphipods—												
Hyperia	1	1	1	—	1	—	—	—	—	—	—	—
Paramoeia	—	—	—	1	—	—	—	—	—	—	—	—
Euthemisto	—	—	—	1	—	—	—	—	—	—	—	—
Unidentified	—	—	—	1	—	—	—	—	—	—	—	—
Stomatopods—												
Squilla	—	2	—	3	1	4	—	—	—	—	—	4
Unidentified	1	5	1	10	1	—	—	1	2	2	1	3
Euphausiids	—	1	—	2	—	—	—	—	—	—	—	—
Isopods—												
Paradotea	—	—	—	—	—	—	—	—	—	—	1	—
Cymothoe	—	—	—	—	—	—	—	—	—	1	—	—
Cirolana	—	—	—	—	—	1	1	—	1	—	—	—
Eurydice	—	—	—	—	—	—	1	—	—	—	—	—
Unidentified	1	—	—	—	1	—	—	—	—	—	—	1
Mysids	1	—	—	—	—	—	—	—	—	3	1	—
Copepods	—	—	—	—	—	—	—	—	—	1	1	—
Unidentified	—	—	—	—	1	2	1	—	—	—	2	—
Polychaetes	—	1	—	1	1	1	6	4	1	6	2	—

TABLE 11.—Combinations of Prey in Stomachs of 84 Penguins captured at Sea in 1956.

Species.	*Sardinops.*	*Trachurus.*	*Engraulis.*	*Etrumeus.*	*Scomber.*	*Scomberesox.*	*Ammodytes.*	*Gonorhynchus.*	Other fish.	Cephalopods.	Crustaceans.	Polychaetes.
Sardinops	(5)	5	8	4	1	1	1	2	3	10	5	2
Trachurus	5	(3)	6	2	1	0	3	2	9	13	6	2
Engraulis	8	6	(0)	2	0	1	2	1	4	9	1	3
Etrumeus	4	2	2	(3)	0	0	0	4	5	5	3	1
Scomber	1	1	0	0	(1)	1	0	0	1	3	1	0
Scomberesox	1	0	1	0	1	(0)	0	0	0	2	0	0
Ammodytes	1	3	2	0	0	0	(2)	0	1	0	1	0
Gonorhynchus	2	2	1	4	0	0	0	(1)	4	1	1	0
Other fish	3	9	4	5	1	0	1	4	(1)	19	11	0
Cephalopods	10	13	9	5	3	2	0	1	19	(3)	7	4
Crustaceans	5	6	1	3	1	0	1	1	11	7	(1)	1
Polychaetes	2	2	3	1	0	0	0	0	0	4	1	(1)

TABLE 12.—Combinations of Prey in Stomachs of 247 Penguins collected at Sea during 1954–56.

Fish only	64
Fish and cephalopods	70
Fish, cephalopods and crustaceans	38
Fish and crustaceans	25
Fish, cephalopods, crustaceans and polychaetes	6
Fish, cephalopods and polychaetes	9
Fish, crustaceans and polychaetes	2
Fish and polychaetes	3
Cephalopods only	5
Cephalopods and crustaceans	4
Crustaceans only	6
Crustaceans and polychaetes	2
Polychaetes only	2
Empty stomachs	11

TABLE 13.—Percentage Frequency of Occurrence of major Prey in 247 Stomachs of Penguins collected at Sea during 1954–56.

Prey.	Reference Areas.					
	1.	2.	3.	4.	5.	6.
	%	%	%	%	%	%
Maasbanker	6	14	49	18	3	10
Pilchard	4	13	26	18	21	18
Anchovy	5	10	35	15	22	13
Round herring	6	—	50	19	25	—
Sandeel	7	13	40	13	13	13
Sandcord	—	5	47	11	11	27
Mackerel	—	5	50	10	10	25
Skipper	—	—	67	—	33	—
Cephalopods	10	12	43	16	9	10
Crustaceans	9	4	52	23	8	4

TABLE 14.—Length Frequencies of Pilchards, Maasbankers and Anchovies captured by Penguins at Sea during 1954–56.

Length (cm.).	Pilchards.		Maasbankers.		Anchovies.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
0– 5	14	10	328	53	412	47
6–10	29	20	236	37	265	30
11–15	38	26	49	8	197	23
16–20	17	12	12	2	—	—
21–25	45	31	—	—	—	—
over 26	2	1	—	—	—	—

TABLE 15.—Amount of Food in Stomachs of 247 Penguins captured at Sea during various Hours of the Day (1954–56).

Time of day.	Number of specimens.	Stomachs without food.	Total weight (gm.).	Mean weight of food in stomachs with food.	Mean weight of food in all stomachs.
0600–0700	1	0	22	22	22
0701–0800	4	0	80	20	20
0801–0900	36	2	3,456	101·7	96
0901–1000	55	6	5,808	118·5	105·4
1001–1100	52	7	5,202	115·6	100
1101–1200	31	2	3,463	119·0	111·8
1201–1300	21	2	3,663	192·6	174·5
1301–1400	23	1	3,223	146·5	140·1
1401–1500	13	1	2,393	199·4	184·1
1501–1600	5	0	469	93·8	93·8
1601–1700	6	0	560	93·3	93·3

TABLE 16.—Amount of Food taken at Meals by 45 Penguins collected at Sea during 1954–56.

Time of day (SAST).	Number of specimens.	Total weight of food. (gm.)	Average weight of food. (gm.)	Mean weight of ultimate meal. (gm.)	Mean weight of penultimate meal. (gm.)
0800	7	1,936	276	262	trace
0900	9	3,156	351	339	trace
1000	7	2,114	302	279	159
1100	5	1,531	306	287	97
1200	8	3,257	407	384	73
1300	4	1,608	402	401	5
1400	4	1,465	366	366	—
1500	1	265	265	265	—

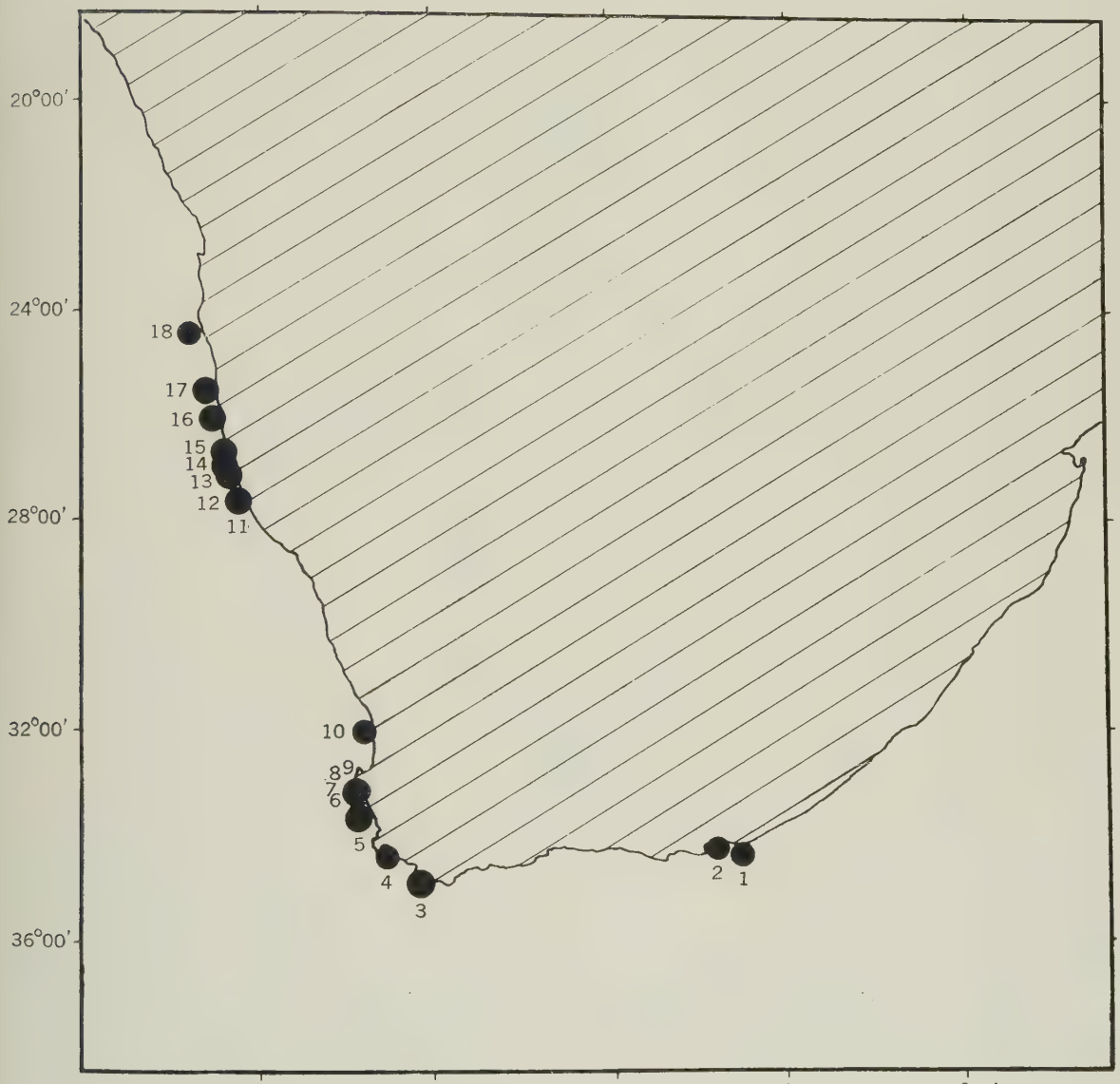

PLATE I LOCATION OF PENGUIN ISLANDS.

Trigsurvey, 1959. Government Printer, 1960.

PLATE II VENTRAL PLUMAGE PATTERN OF CAPE PENGUIN.

Government Printer, 1960.

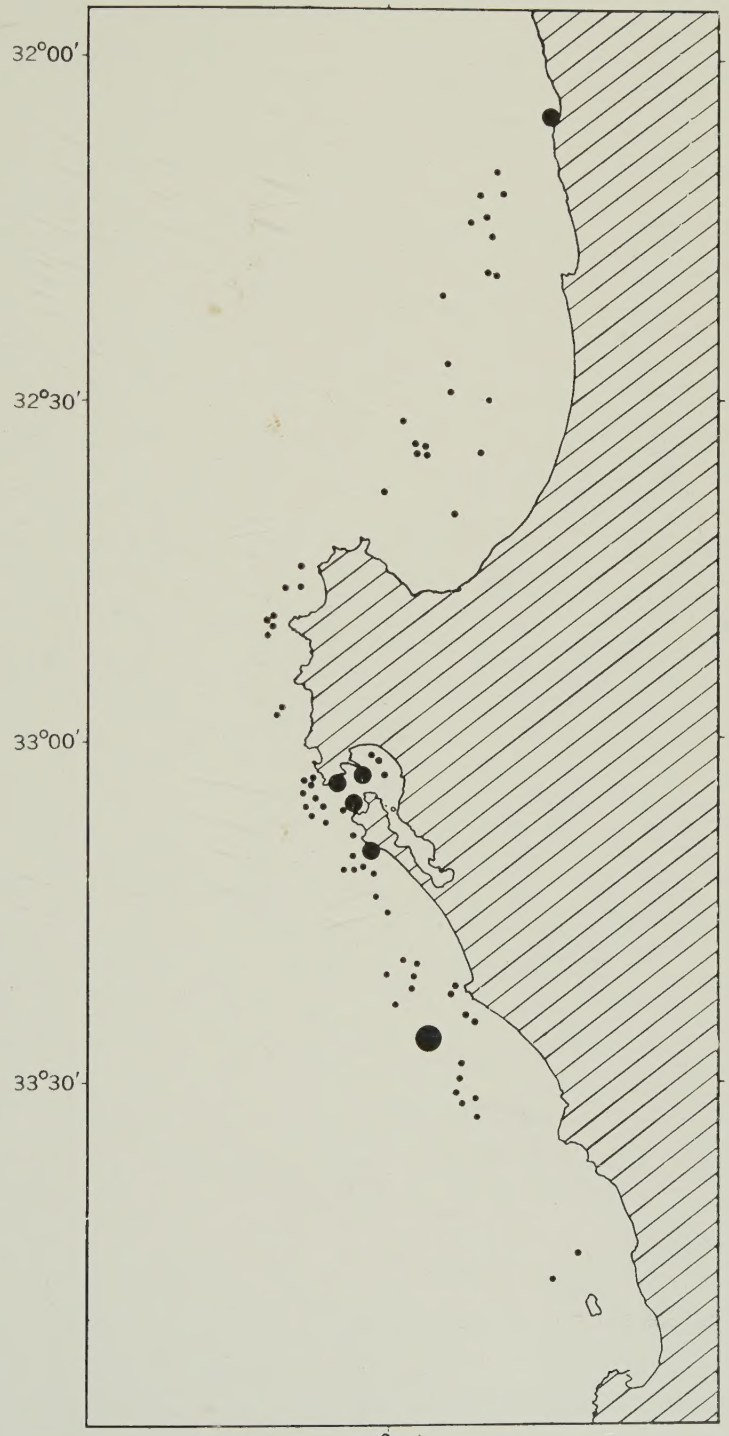

PLATE III DISTRIBUTION OF PENGUINS OFF THE WESTERN CAPE PROVINCE

Trigsurvey, 1959. Government Printer, 1960.

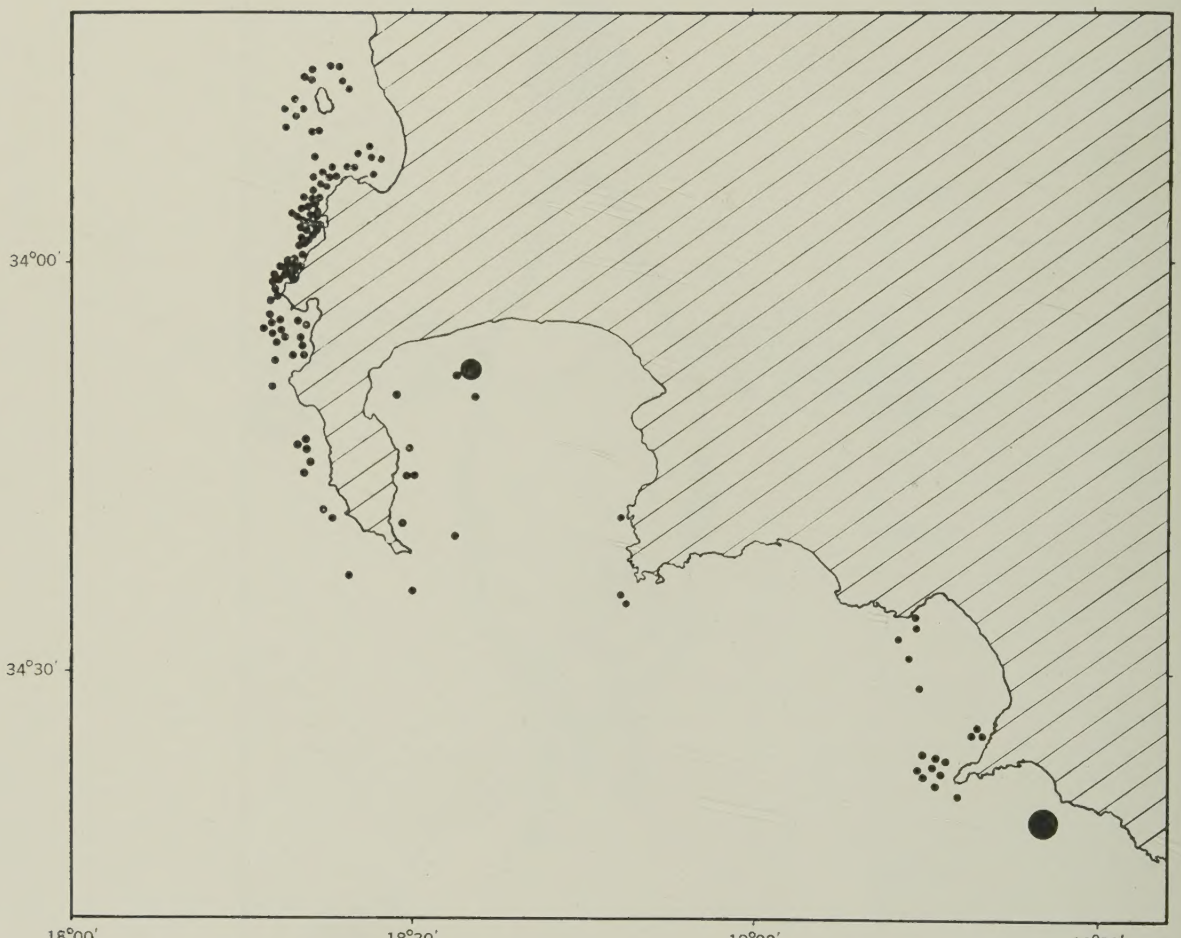

PLATE IV DISTRIBUTION OF PENGUINS OFF THE SOUTH-WESTERN CAPE PROVINCE

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